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Abstract

Present study reviews empirical research studies related to learning science in online learning environments as a community. Studies published between 1995 and 2015 were searched by using ERIC and EBSCOhost databases. As a result, fifteen studies were selected for review. Identified studies were analyzed with a qualitative content analysis method suggested by Li and Tsai (2013). Content from the studies regarding social interaction in online learning environments while teaching or learning science were analyzed to identify research purposes, theoretical foundations, and learning foci. Results indicated of the 15 studies, six studies were built on a specific learning theory. Of the 15 studies, eleven indicated that their focus was socio-contextual learning. Scientific process was studied in eight studies. Six focused on scientific knowledge, five focused on engagement, four considered effect as their focus, and one studied problem solving. The importance of online learning environments for learning science was pointed to better integrate technology and education.

Introduction

Sociocultural learning theory advocates and promotes that teaching and learning science should not be separated from the society and culture in which it is situated. One characteristic of the sociocultural perspective is that each member of society is different by which communities they have lived in and also which roles they have chosen or been assigned to. According to the sociocultural perspective, socially learned traditions of useful scientific discourses and representations are primary to learning and doing science. In addition, if teachers would like to change a concept of science education in students' minds, they need to change something in students' lives and identities (Lemke, 2001). Our environment and the mission that we undertake in this particular environment affect our learning and understanding of science. Teachers and students should be aware that those places where all the scientific activities and theories are being discussed are not limited to the classroom. There are people beyond the classroom discussing scientific issues. Therefore, teachers should engender a classroom community in which students determine their roles that would change over time and work in a collective manner (Book & Putnam, 1992).

The concept "communities of practice" is viewed as a group of people who have a common interest or a passion to do or learn how to do by interacting continuously (Lave & Wenger, 1991; Wenger, 1998). Community of practice is not a new concept but consists of knowing and learning in terms of culture and practice. In a variety of fields (e.g., education, health, economics, business, and etc.), researchers and practitioners are focusing on communities of practice to improve their performance (Lave & Wenger, 1991). This concept has been around for several years, but no one had named it until Lave and Wenger did. As an example, an apprenticeship occurred between a craft and his employee in a workplace (Hildreth & Kimble, 2004).

Individuals—members of a community of practice—actively get involved in a process of collective learning, that is, a group of scientists or engineers in a lab seek for a solution to a problem or a group of educators endeavor to design a new curriculum. People in such communities can come together in light of their needs or interests in a specific domain and/or field, or they can mutually engage in activities to use and produce knowledge to sustain their membership (Lave & Wenger, 1991). The most important feature of a community of practice is that members share their knowledge and experiences with others and learn from each other; therefore, they develop themselves personally and professionally, meaning that they develop identities over time (Lave & Wenger, 1991).

Communities of practice can be seen at various places such as classrooms, laboratories, and kitchens and even online environments. Recently, using online learning environments for teacher professional developments and student learning has gained prominence among researchers (Baran & Cagiltay, 2006; Correia & Davis, 2008; Delen, Liew, & Willson, 2014; Kirschner & Lai, 2007). At the beginning of the 1980s, studies that conceptualize, design, and deliver online classes to the students at different places initiated a new trend: distance education (Harasim, 1999). Over the years, online learning environments have been improved by using communication technologies to spread information and increase interactions among individuals (Harasim, 1990; Johnson & Aragon, 2003). Yet, an effective technological use is just one piece of the continuum underlying a successful online community. A useful and advanced technology should consider social process while creating an online learning community (Garber, 2004). In this article, I will seek an answer to the question of "How communities of practice in online learning environments cultivate the sociocultural perspective of science education" and try to draw a conclusion.

Theoretical Framework

Social Learning Theory

From the Vygotskyan perspective, social interaction is a necessary and central component of learning and not just supplementary (Cole, 1996; Leontiev, 1978; Vygotsky, 1963). Social interaction between people in a laboratory through collaboration or in a classroom through dialogue is just a narrow view of socialization. However, the social learning theory suggests that human social activities are all over the place such as schools, workplaces, hospitals, Internet portals, or listserv groups. And all these communities are heterogeneous and individuals choose or are assigned to different roles in different institutions (Lemke, 2001).

Since we don't know why we act as we do except for a small number of reasons, limited time and context, the sociocultural view of science education is skeptical and critical. This perspective on science education was formed by developments in the social and human sciences because researchers in science education are interested in cognitive psychology or how people learn (Lemke, 2001). For example, in the middle of the 20th century, Julian Rotter (1954) suggested that not only do psychological factors have an impact on learning, but also environmental factors have an important role in learning. According to Rotter, a person models, imitates, and adopts the desired behavior. Therefore, environmental factors such as role models, culture, and society are important for the learning process.

In the same line with Rotter, Albert Bandura (1977), by including Vygotsky and Lave, put forward social learning theory. Social learning theory created a framework for researchers studying on cognitive sciences. This framework accounts for external factors or incentives affecting learners, environmental relations of learners, and cognitive processes of learners (Bandura, 1977). Educational researchers also use social learning theory to understand how external and environmental factors affect learners' latent thought processes. Thus, educational researchers can create better learning environments and design better instructions to assist a community of learners.

Communities of Practice

Wenger (2015) states "learning could be the reason the community comes together or an incidental outcome of member's interactions" (p. 1). Since there have been three crucial characteristics of a community of practice, all the communities are not communities of practice. A community of practice is not just a group of people or a network connection. A community of practice should have a common domain, an interacting community, and a shared practice (Wenger, 1998, 2015). A domain describes the identity of a community. The domain gives the responsibility to the members of a community and separates them from others. The members are not supposed to be experts in this particular domain; members of the community may not even know that they are in a network (Nickols, 2003). In short, a domain creates a shared stage, promotes participation, leads members to learn, and attributes a meaning to their behaviors (Wenger, 2015). Combining these three factors (i.e., a common domain, an interacting community, and a shared practice) can constitute a community of practice.

A community of practice is not only a group of people who have common interests, but also a group of people who are practitioners. In order to create a community of practice, researchers need three elements: (1) mutual engagement, (2) joint enterprise, and (3) shared repertoire (Wenger, 1998). To provide mutual engagement, members of a community of practice should build norms and collaborative relationships that are bonds that tie the members of community together. Therefore, this community of practice creates a social institution (Wenger, 2010). For a joint enterprise, members of a community of practice should create a common understanding of why they are together. Joint enterprise can be created through social interaction. As stated earlier, the domain of the community may cause the term ‘joint enterprise’. As a product of their practice, members of a community of practice generate a shared resources called as ‘shared repertoire’. Shared repertoire can be a set of stories, cases, or experiences that were produced as a result of practice. This sharing requires a continuing interaction and a certain amount of time. To sum up, practice is the main component that makes meaningful behaviors of a community of interests (Wenger, 1998). From the perspective of community of practice, as a social learning theory, a learning environment cannot be an isolated world in which students gain knowledge in order to apply it outside of the classroom (Schlager & Fusco, 2003; Wenger, 1998). Therefore, researchers should consider new technologies, such as the Internet, to provide an interaction among people distributed to different geographical areas. Also, Internet is an easy way of sharing resources.

Online learning environments may be a venue for people sharing a common interest and mutually interacting with each other and generating a set of resources to sustain their learning and knowing (Baran & Cagiltay, 2006; Correia, & Davis, 2008; Gannon-Leary, & Fontainha, 2007; Johnson, 2001; Kirschner & Lai, 2007; Lai, Pratt, Anderson, & Stigter, 2006; Moule, 2006). People who follow their interests in a specific domain, participate in the activities and discussions, and learn from each other build a community of practice. A group of people in an online environment or a group of people working in the same place will not be a community of practice unless they interact and learn from each other. For example, students in a high school or people working in a hospital may have many commonalities; however, if they do not learn from each other, they cannot be named as a community of practice.

Finally, members of a community of practice may not work together necessarily in the online learning environments. People can work alone on daily basis in the online learning environments but still can interact and learn from each other (Wenger, 1998). As an example, students in a group can access an online classroom at different times, read their friends’ posts, and write a post in response to those posts. In this way, students can collectively build knowledge, interact with their peers, and learn from each other (Kelly, Gale, Wheeler, & Tucker, 2007).

Online Learning Environments

In the recent decades, the Internet lived an instant growth in terms of online learning environments such as cyber schools, online campuses, and electronic classrooms (Atici & Polat, 2010; Zhang & Quintana, 2012; Woiwode & Baysingar, 2015). This rapid growth directed the attention of higher education institutions to offering online degree programs (Dringus & Terrell, 1999). Dringus and Terrell (1999) state that an online learning environment is a different, pedagogically meaningful, and wide-ranging learning environment in which teachers and learners can participate in the process at any given time and place. The rapid increase in usage of Internet also affected the growth of online learning communities (Karahan & Roehrig, 2015; Preece, 2001; Preece, Maloney-Krichmar, & Abras, 2003; Wendt & Rockinson-Szapkiw, 2015). Nowadays people are evolving into the online communities and sharing their experiences and information (Lai et al., 2006; Ritter & Delen, 2013). In order to design a successful online community of practice, researchers should understand social pedagogical and organizational aspects of the field and the objectives of similar studies (Schlager, Fusco, & Schank, 2002). There are some obstacles that online communities of practice should overcome: time, size, affiliation, and culture (Wenger et al., 2002).

The design of online learning environments is not culturally neutral but conversely depended on epistemological factors, learning theories, and social goals (Kerlin, 2009; McLoughlin & Oliver, 2000). Researchers should consider that all the members of an online community of practice might come from different cultural backgrounds (Kerlin, 2009). For example, members in a global context probably speak different languages. Language issues are more complex than translating words and establishing bilingual websites. Therefore, culture definitely has an effect on the level of communication, development of trust, and usage of technology (Lai et al., 2006). In this study, social interactions occurred and online learning environments were explored. Researchers studying online learning environments have focused on different aspects of such environments such as design elements, learning outcomes, and different pedagogies.

The main purpose of the present study was to provide an overview of current interest regarding research on online learning environments and to view how researchers studied social interactions in online learning environments through the communities of practice lens. Studies investigating social interactions of students may actually be looking for pieces of a virtual community of practice. These pieces, as described earlier, are mutual engagement, joint enterprise, and shared repertoire. Through this lens, how students meet at the same interests, how they undertake joint projects, and how they share the resources were explored in the reviewed studies.

Method

Study Selection Process

In this study, research studies related to learning science as a community in online learning environments between the years of 1995 and 2015 were scanned in ERIC and EBSCOhost databases as these databases provide the widest coverage of educational research. Education Resources Information Center (ERIC) is an online digital library that provides a comprehensive coverage of education research. EBSCOhost is another database for academic studies in many disciplines.

In this review, only journal articles, master theses, and doctoral dissertations were considered for a better quality of analysis. In addition, studies only written in English were reviewed because the author does not possess enough skills for other languages. At the first step, in both databases, “science education” and “online learning environment” were used as the keywords. Also, the Boolean Operator “AND” was used to limit the search. At the end of the search, 70 journal articles, master theses, and doctoral dissertations were found. At the second step, titles and abstracts of all 70 studies were read to identify target studies. After a thorough reading, studies selected to be reviewed based on the following criteria: (1) studies which are related to science education, (2) studies which provide empirical data, (3) studies which occur in online learning environments, and (4) studies which are available as full text. Studies on both K-16 students and teachers were accounted. Books, literature reviews, and theoretical studies were eliminated from the study. As a result of study selection process, 15 empirical studies that focus on science education in online learning environments with either students or teachers were identified for review. The remaining 55 studies were either not related to science education or online learning environments or did not provide empirical data. Table 1 presents studies that were included in the present study by author names and years.

Table 1. Reviewed studies and their types

Year	Author(s)	Study Type
2007	Jones & Kalinowski	Journal Article
2008	Raeside, Busschots, Waddington, & Keating	Journal Article
2008	Clark & Sampson	Journal Article
2009	Kerlin	Doctoral Dissertation
2010	Atici & Polat	Journal Article
2010	King, Greidanus, Carbonaro, Drummond, Boechler, & Kahlke	Journal Article
2012	Evagorou, Jimenez-Aleixandre, & Osborne	Journal Article
2012	Zhang & Quintana	Journal Article
2013	McConnell, Parker, Eberhardt, Koehler, & Lundeberg	Journal Article
2013	Wolter, Lundeberg, Bergland, Klyczek, Tosado, Toro, & White	Journal Article
2015	Karahan & Roehrig	Journal Article
2015	Marsteller & Bodzin	Journal Article
2015	Woiwode & Baysingar	Master Thesis
2015	Wendt & Rockinson-Szapkiw	Journal Article
2015	Strømme	Doctoral Dissertation

Data Analysis

Studies identified for review were analyzed with a content analysis method. In data analysis process, the method used by Li and Tsai (2013) was adapted. Content from the studies regarding social interaction in online learning environments while teaching or learning science were analyzed to identify research purposes, theoretical foundations, and learning foci. By analyzing research questions, research purposes of the studies were determined. By analyzing introduction, literature, and methodology parts, theoretical foundations of the studies were analyzed and categorized into the following categories: (1) theory, (2) model, (3) approach, and (4) principle (Li & Tsai, 2013). When analyzing theoretical foundations, an explicit theory such as “social learning theory” was searched first. If a theory was not identified in the background, then other theoretical levels were considered. Based on the given details in the background, other theoretical levels of the studies were identified as model, approach, or principle, depending on which one suited best.

Table 2. Categories, descriptions, and examples for learning focus (adapted from Li and Tsai, 2013, p. 882)

Learning Focus	Description	Example Studies
Scientific knowledge	To obtain or increase the knowledge or concepts (e.g., facts, ideas, models, relationships) of a targeted science domain (e.g., physics, chemistry, biology, earth science)	Atici & Polat (2010) – Student success and opinions
Scientific processes	To learn or perform the scientific methods including observing, explaining, predicting, investigating, interpreting and concluding	Jones & Kalinowski (2007) – Scientific process skills
Problem-solving	To learn to solve problems or to perform the cognitive process of problem-solving (e.g., understanding, characterizing, representing, solving, reflecting, communicating and reasoning)	Evagorou et al. (2012) – Decision making skills
Affect	To investigate the affective side of science learning such as attitude, motivation, and interest	Woiwode & Baysingar (2015) – Outcomes of test scores and grades
Engagement	To investigate students' involvement in learning including cognitive, affective, and behavioral engagement	Raeside et al. (2008) – Authentic scientific engagement
Socio-contextual learning	To emphasize the social or contextual aspects of science learning	Clark & Sampson (2008) – Quality of dialogic argumentation

Finally, by analyzing research questions, purposes, hypotheses, instruments, and results, learning foci of the studies were analyzed and categorized into the following categories: (1) scientific knowledge, (2) scientific processes, (3) problem-solving, (4) affect, (5) engagement, and (6) socio-contextual learning. In many of these studies, multiple outcomes were assessed. Therefore, the learning foci of these studies were placed in multiple categories. Li and Tsai (2013) identified these categories based on the literature of science and online learning (see Table 2).

Results

Results of the reviewed studies were gathered in three tables. As presented in Table 3, 11 of 15 reviewed studies were published after 2010. No relevant study was found before 2007. Most of the studies were related to learning physics (6) and biology (4). The other studies were related to chemistry (2), health science (2), general science (1; McConnell et al., 2013), and environmental science (1; Karahan & Roehrig, 2015). Researchers in each study used different online learning environments. While some of these environments were familiar for those who have been involved in online learning environments such as Moodle, Edmodo, and blogs (Atici & Polat, 2010; Wendt & Rockinson-Szapkiw, 2015), the other environments were unique to the studies in which they were used such as Web-based Inquiry Science Environment (WISE).

Participants for five studies were elementary school students, four studies were high school students, four studies were college students, one study was teachers (McConnell et al., 2013), and two studies had both elementary and high school students. Researchers in eight studies preferred to use case study as their research method, while other researchers preferred quasi-experimental design. In only one study (i.e., Atici & Polat, 2010), researchers used experimental design.

Research purposes of the online learning environment studies were gathered in four categories. These categories were labeled as (1) online learning environments improving science learning, (2) social interactions of learners in online learning environments, (3) scientific discourse of learners in online learning environments, and (4) instructional usage of online learning environments. Table 4 presents the purpose of each study. Improving science learning was the most common research purpose used by seven studies. For example, King et al. (2010) explored how participants using synchronous technology solve problems of science and improve their skills. Participants, in this study, engaged in a joint enterprise to solve the problem and interacted with each other. In addition, Wolter et al. (2013) investigated student performance by presenting a "real world" problem through an online learning environment. In order to solve the problem, students used virtual labs and disseminated their findings using posters.

Instructional usage of online learning environments was the second most common research purpose used by six studies. As an example, Atici and Polat (2010) analyzed how instructional usage of online tools affected students' opinions. Findings of this study revealed that majority of students thought an online course positively affected their practices in doing science. Eight studies focused on either social interaction of learners or scientific discourse of learners in online learning environments. For instance, Raeside et al. (2008) explored how online learning environments cultivated social interaction among students and teachers. Researchers in this study examined social interactions of students and teachers by evaluating 52 research reports of students and surveying 14 teachers. Moreover, Evagorou et al. (2012) explored how students from different backgrounds argued about the same socio-scientific issue to justify their decisions. Students using evidence presented in the learning environment developed their arguments for the given socio-scientific issue. Results revealed that students from different backgrounds approach the socio-scientific issue from different perspectives.

Table 3. Background information of reviewed studies

Author(s)	Science Domain	Online Learning Environment	School Level of Participants	Number of Participants	Research Method
Jones & Kalinowski (2007)	Physics	Mars 3D online	College	16	Quasi-Experimental
Raeside et al. (2008)	Physics	Education through Virtual Experience (EVE)	Elementary and High school	200	Case Study
Clark & Sampson (2008)	Physics	Web-based Inquiry Science Environment (WISE)	Elementary school	84	Case Study
Kerlin (2009)	Physics	From Local to Extreme Environments (FLEXE)	Elementary and High school	1419	Quasi-Experimental
Atici & Polat (2010)	Chemistry	Moodle and Blogspot	Elementary school	45	Experimental
King et al. (2010)	Health Science	Elluminate Live	College	20	Case Study
Evagorou et al. (2012)	Biology	Argue-WISE	Elementary school	57	Case Study
Zhang & Quintana (2012)	Chemistry	Digital Idea-Keeper	Elementary school	16	Quasi-Experimental
McConnell et al. (2013)	General Science	Marratech and TeacherTube	Teachers	54	Case Study
Wolter et al. (2013)	Biology	Case It!	College	105	Case Study
Karahan & Roehrig (2015)	Environmental Science	Ning Social Network	High school	22	Case Study
Marsteller & Bodzin (2015)	Biology	CourseSitesi	High school	77	Case Study
Woiwode & Baysingar (2015)	Health Science	The Sakai	College	106	Quasi-Experimental
Wendt & Rockinson-Szapkiw (2015)	Physics	Edmodo	Elementary school	84	Quasi-Experimental
Strømme (2015)	Physics and Biology	Viten.no and SCY-Lab	High school	91	Quasi-Experimental

Theoretical foundations of the reviewed studies were examined in four categories: (1) theory, (2) model, (3) approach, and (4) principle (see Table 5). Of the 15 studies, six indicated that their studies were built on a specific learning theory. For example, Raeside et al. (2008) and Karahan and Roehrig (2015) stated that underneath their studies social constructivist theory lies. In addition, Kerlin (2009), Wendt and Rockinson-Szapkiw (2015), and Strømme (2015) explained social learning theory (sociocultural theory) as the theoretical foundations of their studies. Five of the reviewed studies indicated that they used a model to represent the theoretical foundations of their studies. As an example, King et al. (2010) defined e-problem-based learning as the pedagogical model used in their study. Moreover, Wendt and Rockinson-Szapkiw (2015) used collaborative learning to compare online learning environments and face-to-face learning environments. Clark and Sampson (2008) was one of the four studies that used an approach as their theoretical foundation. In this study, researchers choose dialogic argumentation approach to assess. Of the three studies using a principle as their theoretical foundation, Zhang and Quintana (2012) explored the effect of learner-centered design on students' scientific processes.

Table 4. Research Purposes of the online learning environment (OLE) studies

Author(s)	OLE Improving Science Learning	Social Interactions of Learners in OLE	Scientific Discourse of Learners in OLE	Instructional Usage of OLE
Jones & Kalinowski (2007)	X			
Raeside et al. (2008)		X		
Clark & Sampson (2008)			X	
Kerlin (2009)			X	
Atici & Polat (2010)				X
King et al. (2010)	X			X
Evagorou et al. (2012)			X	X
Zhang & Quintana (2012)	X			
McConnell et al. (2013)			X	
Wolter et al. (2013)	X			X
Karahan & Roehrig (2015)			X	
Marsteller & Bodzin (2015)	X			X
Woiwode & Baysingar (2015)	X	X		
Wendt & Rockinson-Szapkiw (2015)		X		
Strømme (2015)	X			X

Learning foci of the reviewed studies were examined in six categories: (1) scientific knowledge, (2) scientific processes, (3) problem-solving, (4) affect, (5) engagement, and (6) socio-contextual learning (see Table 2). Table 5 presents the learning focus of each study. Of the 15 studies, eleven indicated that their focus was socio-contextual learning. For instance, McConnell et al. (2013) examined how learning context differed between online professional learning communities and face-to-face professional learning communities. Another example is Wendt and Rockinson-Szapkiw's (2015) study in which researchers examined the effect of online versus face-to-face collaborative learning on adolescent sense of community in the physical science classroom. Scientific process was studied in eight studies. For example, Jones and Kalinowski (2007) explored the effects of Mars 3D online learning environment on pre-service teachers' scientific process skills and interest toward science. Out of the 15 reviewed studies, six focused on scientific knowledge, five focused on engagement, four considered effect as their focus, and one researched problem solving.

Discussion

A benefit of online learning environments in science education from the sociocultural perspective is that educators can create common culture, values, and ethics for students because science education is becoming a global enterprise and students are coming from various cultures. It is undeniable that the context in which students' learning occurs is becoming larger and larger. Community beliefs, identities, and students' lives outside the classroom affect students' interest in, attitudes toward, and motivation toward science (Lemke, 2001). These social factors can be manipulated by establishing a community of practice in online learning environments.

Lemke (2001) states that researchers should discover the best way of teaching science that meets the different needs of heterogeneous and diverse classroom communities. Following this aim, researchers who are working on new information and communication technologies in science education are the most positive. These new technologies will cause an essential change in science education by providing new opportunities to heterogeneous classroom communities. Some examples are giving students the chance to interact with a global pool of mentors, creating network-mediated peer-group projects and space to keep electronic portfolios, and assisting with private curricula and instructions (Lemke, 2001). In addition, a body of literature review says that teaching concepts without their social, economical, historical and technological context is inaccurately considering the nature of science (Lemke, 2001). Using an online learning environment may provide such context with its non-traditional instructions, visualization, and embedded interactive simulations (Delen et al. 2014).

Table 5. Theoretical foundations and learning foci of reviewed studies

Author(s)	Theoretical Foundations	Learning Foci
Jones & Kalinowski (2007)	OLE's effect on attitudes of learners (Principle)	Scientific processes Engagement
Raeside et al. (2008)	Social constructivist theory Inquiry-based learning (Theory and Model)	Engagement Socio-contextual learning
Clark & Sampson (2008)	Dialogic argumentation (Approach)	Engagement Socio-contextual learning
Kerlin (2009)	Sociocultural learning theory Argumentation (Theory and Model)	Scientific processes Scientific knowledge Socio-contextual learning Affect
Atici & Polat (2010)	Instructional usage of online tools (Principle)	Scientific knowledge Socio-contextual learning Affect
King et al. (2010)	E-Problem-based learning (Model)	Engagement Socio-contextual learning Scientific processes
Evagorou et al. (2012)	Dialogic Argumentation (Approach)	Scientific processes Problem-solving Socio-contextual learning
Zhang & Quintana (2012)	Learner-centered design (Principle)	Scientific processes Engagement
McConnell et al. (2013)	Problem-based learning (Model)	Socio-contextual learning Scientific processes
Wolter et al. (2013)	Cased-based instruction (Model)	Scientific knowledge Affect Socio-contextual learning
Karahan & Roehrig (2015)	Constructionism theory Social constructivist theory (Theory)	Scientific processes Socio-contextual learning
Marsteller & Bodzin (2015)	Social cognitive theory Situated learning theory (Theory)	Scientific knowledge Scientific processes
Woiwode & Baysingar (2015)	Community of inquiry (Approach)	Scientific knowledge Affect
Wendt & Rockinson-Szapkiw (2015)	Social learning theory Collaborative learning (Theory and Model)	Socio-contextual learning
Strømme (2015)	Socio-cultural perspective (Theory)	Scientific knowledge Socio-contextual learning

Studies reviewed in this article presented an insight regarding research on learners' science practices in online learning environments from a sociocultural perspective. Publication years of the reviewed studies reveal that this topic is gaining prominence among researchers in recent years. However, a couple of issues were unveiled through present research. For example, about 40% of the studies relied on a theory. Therefore, a majority of studies did not specify a theory when designing their research and the online learning environment they used.

Researchers would have benefited from such theories in designing online learning environments to better integrate technology and education (Li & Tsai, 2013). In addition, although the majority of the studies indicated that their learning focus was sociocultural learning, expectation was seeing sociocultural perspective in all the studies because researchers at the beginning of their studies promised to explore social interactions. Only three studies analyzed learners' social interactions in online learning environments. Nevertheless, findings from all the studies were promising for future of learning science through online learning environments.

By viewing the reviewed studies through the community of practice lens, social interactions in online learning environments were also examined. None of these studies explicitly indicated that they were looking for pieces of a virtual community of practice (i.e., mutual engagement, joint enterprise, and shared repertoire). However, they implicitly explored how students met at the same interests, how they undertook joint projects, and how they shared the resources. For example, Raeside et al. (2008) used the interactive learning environment (EVE) that had potential properties to promote communities of practice while learning and doing science. This online learning environment allowed students to collaboratively create research reports, store data, give and receive feedback, and analyze data. In this online learning environment, about 200 students created a community of practice in which they met at the same interest, engaged in the same enterprise, and generated a shared report (i.e., 52 student reports).

Clark and Sampson (2008) also used an interactive online learning environment, named as Web-based Inquiry Science Environment (WISE). This learning environment allowed students to create a formal argumentation, interact with each other, and form epistemic reasoning. In this study, Clark and Sampson (2008) provided evidence that students created a community of practice by engaging in a scientific discourse and gaining scientific knowledge through their practices. Kerlin (2009) extended Clark and Sampson's endeavor by including international students into the scientific discourse at an online learning environment (i.e., From Local to Extreme Environments [FLEXE]). In this study, students partnered with international students to work on an energy unit. 1,419 students across the world engaged in scientific discourse that led them to collect and analyze data and share the scientific knowledge generated in these practices.

King et al. (2010) by focusing on interprofessional team skills also examined students' practices to find a solution for a scientific problem. Twenty college students using Elluminate Live online learning environment communicated and collaborated to solve the given problem. This study provided evidence regarding that such a synchronous online learning environment could effectively cultivate students' team process skills in doing their joint enterprise. Results also indicated communication and collaboration through Elluminate Live facilitated student learning which allowed students to create a shared repertoire. Evagorou et al. (2012) conducted a study focused on students' practices regarding a socio-scientific issue. In this study, 57 elementary school students engaged in an argumentation on a given socio-scientific issue. Students from different backgrounds by using Argue-WISE online learning environment approached to the socio-scientific issue from different perspectives. Findings of this study gave more importance to the students' scientific process skills than their practices for a shared repertoire.

Wolter et al. (2013), by using Case It online learning environment, also put forward a "real world" problem for students to solve. A hundred and five college students studying biology attempted to solve this problem involving discussions, testing their hypotheses through simulations, creating posters, and giving and receiving feedback. Results of this study revealed that regardless of teachers' students' practices in Case It! online learning environment increased their learning. In a different study, Karahan and Roehrig (2015) used Ning Social Network to provide an environment for students in which they could express environmental awareness and activism. Through this learning environment, students engaged in a joint video project that increased their environmental awareness and perceived need for activism against climate change.

Finally, Wendt and Rockinson-Szapkiw (2015) used Edmodo educational platform to increase students' sense of community. Eighty-four elementary school students engaged in collaborative activities that allowed them to construct an answer to a given problem, share their answers, discuss their answers, and give feedback to each other. By meeting at the same interests, practicing collaboratively, and generating shared knowledge, students in these studies could establish communities of practice. Researchers in some of the reviewed studies described how students created communities of practice without mentioning the term, but we can still see the pieces of communities of practice.

Conclusion and Implications

Considering that sociocultural perspective views science as people actions within the cultural context, this perspective shows some similarities with the communities of practice. Both perspectives suggest that learning occurs between people and the world (Wenger, 2010). Wenger (2010) describes the communities of practice from the lens of social learning theory as follows:

> A community of practice can be viewed as a social learning system. Arising out of learning, it exhibits many characteristics of systems more generally: emergent structure, complex relationships, self-organization, dynamic boundaries, ongoing negotiation of identity and cultural meaning, to mention a few. In a sense it is the simplest social unit that has the characteristics of a social learning system. (p. 1)

Based on the above description, researchers can establish communities of practice in online learning environments. Online learning environments enable people to change elements and constitute a new culture. The new culture can include a domain to attract learners' attention to establish a community in which they practice to understand science. In addition, this new culture can represent a globalized world. Therefore, to establish a community, researchers can find many people from a diverse background. The new culture of online learning environments should define new values and ethics as in all societies. Therefore, the members of a community of practice can interact and learn from each other in a safe and respected environment.

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